A LIQUID SEAL FOR RECOVERING FLARED GAS

Field of the invention

The present invention relates to the recovery of discharged gases and more particularly to provide a liquid seal means forming a device enabling safe recovery of maximum quantity of vented gas; often flared from oil production facilities, refineries, petrochemical plants and the like and thereby reducing the quantity of gas flared to zero.

Background of the invention

In a hydrocarbon plant gas is vented from across the plant and this gas poses a safety hazard. This gas is collected and is burned in a flare so as to reduce the risk of explosion as well as to ensure that uncombusted gas is not released in the atmosphere. There are available various processes by which this gas can be recovered, but not all the gas vented can be recovered as the quantity or the rate of vented gas is not constant. There is also a possibility of an upset in the plant releasing large amount of gas, often exceeding the recovery capacity installed. Such extra volume of gas available in the confined pipeline increases the pressure of gas making the gas difficult to recover. To avoid the possibility of any mishap the available systems are designed in such a way that a permanent flare is maintained by burning the vented gas. The burning of the vented gas involves substantial costs as this gas is very rich in hydrocarbon content and would have been otherwise recovered. Keeping a permanent flare also solves the problem of sudden and unexpected increase in the volume of vented gas as this gas will also be combusted in the flare.

While the gas at a relatively low pressure can be safely recovered, there is always a risk of the said unexpected increase in pressure making the recovery process difficult and unsafe. Another factor to be considered is to ensure that

the recovery of gas does not cause a drop in the pressure of gas in the piping leading to the flare, as it can result in the ingress of atmospheric air into the flaring system creating an explosive mixture in the flare itself; endangering the plant.

An important objective of the present invention is to provide a safe means to allow the recovery of gas, at the same time maintaining utmost safety, and also to prevent the ingress of atmospheric air in the flaring mechanism.

Another important object of the present invention is to provide a seal means capable of breaking instantaneously due to an increase in pressure beyond a predetermined limit, thereby allowing the gas to escape to the flaring mechanism unrestrictedly and being burned safely.

It is a further objective of the present invention to enable total recovery of vented gas thereby reducing the quantity of gas flared to zero during normal operation.

An other important object of the present invention is to provide a means allowing diversion of gas from one flaring system to another flaring system where plurality of flares are used and thereby enabling recovery of gas at a centralized facility.

Summary of the invention

The liquid seal according to the present invention consists of a U-tube having one arm connected to the pipe collecting all the gas vented from across the plant and other arm connected to a liquid holder. A pipe provided at the top of the liquid holder is connected to the gas pipe leading to the flare while there is a pipe at the bottom of the said liquid holder fitted with a non-return valve connecting to the bottom of U-tube. There is provided a drain pipe at the

bottom of U-tube to drain out the liquid if needed.

During normal operations all the vented gas is collected by a pipe and passed on to knock out drum (KOD). Due to the presence of a liquid seal and a piping blind between the KOD and the flare stack, the passage of gas to the flare stack is blocked. The gas passes from the KOD through a line to a recovery system and effectively all vented gas is recovered. As no gas escapes from the plant to the flare stake there is no need to keep the flare burning.

When the pressure of the gas increases in the gas pipe due to increase in the volume of vented gas or due to an upset, there is a resultant increase in the pressure of the gas inside the U-tube which causes displacement of the liquid. An increase in the pressure beyond a predetermined limit causes complete displacement of the liquid from the U-tube; emptying the same to the liquid holder. This instantaneously opens the passage for the gas to escape from the U-tube to the liquid holder and further to the pipe leading to the flare. At this stage the gas enters the liquid holder from the U-tube and then passes on to the pipe which carries it to the flare stack thereby burning it. When sufficient quantity of gas has escaped to the flare stack, there is a resultant drop in pressure inside the U-tube enabling the liquid present in the liquid holder to enter the U-tube, through the pipe provided with a non-return valve, due to the action of gravity and thereby sealing the passage of gas from the U-tube to the pipe leading to the flare stack.

Brief description of the drawings

Further objects, features and advantages of the invention appear from the following description of the exemplary embodiments which are diagrammatically illustrated on the attached drawings, wherein:

Figure **I** shows the liquid seal in the idle condition.

Figure **II** shows the application of a liquid seal for recovery of vented gas

where there is one flare.

Figure **III** shows the liquid seal withstanding pressure.

Figure **IV** shows the liquid seal broken thereby allowing a free passage of gas to the flare stack.

Figure **V** shows the application of a liquid seal for recovery of vented gas where more than one flares are used.

Detailed description of the preferred embodiments

Although following examples shows the operation of specific embodiments, many modifications and variations will readily occur to those skilled in the art, accordingly it is not intended to limit the scope of the invention.

Accordingly with reference to the Figure **I**, the liquid seal comprises of a bent tube, preferably of U shape, such a U-tube having arm **1** connected to the pipe **8** which collects all the gas vented form the plant and arm **2** connected to the liquid holder **5**. A pipe **6** connected to the liquid holder **5** connects to the pipe **9** which leads to the flare stack while a piping **4** provided with a non-return valve **10** connects to the bottom of the U-tube. A drain pipe **3** fitted with a valve is provided at the bottom of the U-tube. The pipe leading to the flare is provided with a blind **11** to block the passage of gas from the plant to the flare stack and also dividing the said pipe; forming pipe **8** and pipe **9.**

In another embodiment of the present invention there is provided a pipe **7** connecting the tip of arm **1** to pipe **6** to supply a limited quantity of gas to the flare stack for equalization at the time of restarting the system after maintenance.

The liquid seal assembly can either forms a part of the pipe leading to the flare stack or can be attached to it as shown in the Figure **II** where it is installed between the knock out drum **13** and the flare stack **15.**

With reference to Figure **II** a line **8A** collects all the gas vented from across the plant and connects to a knock out drum (KOD) **13**. A liquid seal **L1** is installed after the KOD **13** and a pipe **9** connects the liquid seal to the flare stack **15**. A line **12** is provided originating between the KOD **13** and liquid seal **L1** extending to recovery system **14**.

During normal operation all the vented gas is collected by line **8A** and passed on to KOD **13**. Due to the presence of liquid seal **L1** and piping blind **11** between the KOD **13** and flare stack **12** the passage of gas to the flare stack is blocked. The gas passes from the KOD **13** through line **12** to the recovery system **14** and effectively all vented gas is recovered. As no gas escapes from the plant to the flare stake there is no need to keep the flare burning.

When the liquid seal is in operation as shown in Figure **III** there is a pressure applied by the gas on the surface of liquid in arm **1** of the U-tube pushing the liquid in downwards direction. There is a corresponding rise in the level of liquid in arm **2**. The total length if tube is calculated according to the predetermined value of pressure to be handled as well as to ensure that even the creation of vacuum pressure at the recovery process does not lift the liquid out of the liquid seal. In case of an upset in plant or if the volume of vented gas exceeds the recovery capacity installed, the pressure of gas rises in pipe **8**. When, due to a large increase in the volume of gas vented or an upset in the plant, the pressure on the surface of the liquid in arm **1** becomes more than this predetermined value, then the total liquid in the U-tube becomes incapable of exerting a back pressure on the gas and as a result this column of liquid gets displaced completely into the liquid holder **5** breaking the seal instantaneously as shown in the Figure **IV**. This makes the U-tube empty of the liquid; giving a free passage to the gas to escape through the U-tube to the liquid holder **5** and then through the pipe **6** to the pipe **9** and finally to the flare stack. The excess gas escapes from pipe **8** to the pipe **9** through the now broken liquid seal **L1** and finally to the flare stack **15**. In order to prevent the

release of uncombusted gas into the atmosphere, an ignition system ignites the flare, burning all the escaping gas.

Thus the gas at high pressure which was difficult to handle and\or recover gets released safely to the flare stack.

Due to the action of gravity, the liquid in the liquid holder **5** tries to enter the U-tube through the piping **4** provided with a non-return valve **10**. The high pressure of the gas inside the U-tube works against the pressure applied by this liquid, preventing it from entering the U-tube.

As soon as sufficient quantity of gas has escaped to the flare stack or at the normalization of operations, there is a resultant drop in pressure of gas in arm **1** and once this pressure falls below a predetermined limit, the liquid enters the U-tube from the liquid holder **5** through pipe **4** filling the U-tube and sealing it, thereby blocking the passage of gas from the U-tube to the flare; restoring the system to the position shown in Figure **III**. This effectively cuts the supply of gas to the flare and soon the flare gets extinguished.

All the while the recovery process is allowed to continue unhindered and only the gas in excess of the recovery capacity escapes to the flare.

Often at the hydrocarbon production plants, more than one processes are run, thereby leading to plurality of flaring systems. The following example shows the recovery of gas using another embodiment of the present invention in such a situation.

With reference to Figure **V** an another line **8B** collects all the vented gas from an other process and connects to KOD **13A** which connects to a second liquid seal **L2**. A line **9A** connects the liquid seal **L2** to the flare stack **15A**. A line **12A** originating between KOD **13A** and liquid seal **L2** connects to the recovery system **14**. A restricted orifice **16** is provided on line **12A**.

In case of plurality of flaring systems installed as shown in Figure **V** then a line **8B** collects all the vented gas from the second process. The gas is passed on to KOD **13A** and due to the presence of liquid seal **L2** and piping blind **11**, the passage of this gas to the flare stack **15A** is blocked. This gas is carried by line **12A** to the recovery system **14** and all gas is recovered by the recovery system **14**. The gas in the line **12A** has more pressure than the gas in line **12** so the flow of gas through line **12A** to the recovery process **14** is controlled by employing the restricted orifice **16**.

The liquid seal **L2** is capable of withstanding higher pressure than the liquid seal **L1**.

If the pressure of gas in the line **8B** increases beyond a predetermined limit then there is a corresponding increase in the pressure in pipe **8** and this breaks the liquid seal **L1** starting flaring at the flare stack **15**. On a further increase in the pressure beyond a second predetermined limit, the liquid seal **L2** breaks flaring gas in the flare stack **15A**.

With a fall of pressure below the second mentioned predetermined limit, the liquid seal **L2** is restored first, cutting out the supply of gas to the flare stack **15A** and soon flare at flare stack **15A** gets extinguished. Further fall of pressure below the first mentioned predetermined limit restores the liquid seal **L1** cutting out the supply of gas to the flare stack **15**. Soon the flare at the flare stack **15** gets extinguished and at this stage all the vented gas is again recovered.

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Background of the invention

In a hydrocarbon plant gas is vented from across the plant and this gas poses a safety hazard. This gas is collected and is burned in a flare so as to reduce the risk of explosion as well as to ensure that uncombusted gas is not released in the atmosphere. There are available various processes by which this gas can be recovered, but not all the gas vented can be recovered as the quantity or the rate of vented gas is not constant. There is also a possibility of an upset in the plant releasing large amount of gas, often exceeding the recovery capacity installed. Such extra volume of gas available in the confined pipeline increases the pressure of gas making the gas difficult to recover. To avoid the possibility of any mishap the available systems are designed in such a way that a permanent flare is maintained by burning the vented gas. The burning of the vented gas involves substantial loss as this gas is very rich in hydrocarbon content and would have been otherwise recovered. Keeping a permanent flare also solves the problem of sudden and unexpected increase in the volume of vented gas as this gas will also be combusted in the flare.

While the gas at a relatively low pressure can be safely recovered, there is always a risk of the said unexpected increase in pressure making the recovery process difficult and unsafe. Another factor to be considered is to ensure that

the recovery of gas does not cause a drop in the pressure of gas in the piping leading to the flare, as it can result in the ingress of atmospheric air into the flaring system creating an explosive mixture in the flare itself; endangering the plant.

An important objective of the present invention is to provide a safe means to allow the recovery of gas, at the same time maintaining utmost safety, and also to prevent the ingress of atmospheric air in the flaring mechanism.

Another important object of the present invention is to provide a seal means capable of breaking instantaneously due to an increase in pressure beyond a predetermined limit, thereby allowing the gas to escape to the flaring mechanism unrestrictedly and being burned safely.

It is a further objective of the present invention to enable total recovery of vented gas thereby reducing the quantity of gas flared to zero during normal operation.

An other important object of the present invention is to provide a means allowing diversion of gas from one flaring system to another flaring system where plurality of flares are used and thereby enabling recovery of gas at a centralized facility.

Summary of the Invention

The liquid seal according to the present invention consists of a U-tube having one arm connected to the plant and other arm connected to a liquid holder. The arm connected to the plant is preferably longer than the one connected to the liquid holder. The shorter arm opens at the upper portion of the liquid holder above the liquid level and adjacent to or below the passageway connecting the liquid holder to the flare stack. A pipe fitted with a non-return valve connects to the bottom of U-tube to the bottom of the liquid holder. There is provided a drain pipe at the

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where there is one flare.

Figure **III** shows the liquid seal withstanding pressure.

Figure **IV** shows the liquid seal broken thereby allowing a free passage of gas to the flare stack.

Figure **V** shows the application of a liquid seal for recovery of vented gas where more than one flares are used.

Detailed description of the preferred embodiments

Although following examples shows the operation of specific embodiments, many modifications and variations will readily occur to those skilled in the art, accordingly it is not intended to limit the scope of the invention.

Accordingly with reference to the Figure **I**, the liquid seal comprises of a bent tube, preferably of U shape with arms of uneven length, such a U-tube having preferably longer arm **1** connected to the pipe **8** which is connected to the plant and shorter arm **2** connected to upper portion of the liquid holder **5** above the level of the liquid. A pipe **6** connected to the liquid holder **5** connects to the pipe **9** forming a passageway which leads to the flare stack, the opening of U-tube inside the liuqid holder positioned adjacent to or below such passageway, while a piping **4** provided with a non-return valve **10** connects to the bottom of the U-tube. A drain pipe **3** fitted with a valve is provided at the bottom of the U-tube. The pipe leading to the flare is provided with a blind **11** to block the passage of gas from the plant to the flare stack and also dividing the said pipe; forming pipe **8** and pipe **9**.

In another embodiment of the present invention there is provided a pipe **7** connecting the tip of arm **1** to pipe **6** to supply a limited quantity of gas to the flare stack for equalization at the time of restarting the system after maintenance.

The liquid seal assembly can either forms a part of the pipe leading to the flare stack or can be attached to it as shown in the Figure **II** where it is installed between the knock out drum **13** and the flare stack **15**.

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With reference to Figure **II** a line **8A** collects all the gas vented from across the plant and connects to a knock out drum (KOD) **13**. A liquid seal **L1** is installed after the KOD **13** and a pipe **9** connects the liquid seal to the flare stack **15**. A line **12** is provided originating between the KOD **13** and liquid seal **L1** extending to recovery system **14**.

During normal operation all the vented gas is collected by line **8A** and passed on to KOD **13**. Due to the presence of liquid seal **L1** and piping blind **11** between the KOD **13** and flare stack **12** the passage of gas to the flare stack is blocked. The gas passes from the KOD **13** through line **12** to the recovery system **14** and effectively all vented gas is recovered. As no gas escapes from the plant to the flare stake there is no need to keep the flare burning.

When the liquid seal is in operation as shown in Figure **III** there is a pressure applied by the gas on the surface of liquid in arm **1** of the U-tube pushing the liquid in downwards direction. There is a corresponding rise in the level of liquid in arm **2**. The total length of tube is calculated according to the predetermined value of pressure to be handled as well as to ensure that even the creation of vacuum pressure at the recovery process does not lift the liquid out of the liquid seal. In case of an upset in plant or if the volume of vented gas exceeds the recovery capacity installed, the pressure of gas rises in pipe **8**. When, due to a large increase in the volume of gas vented or an upset in the plant, the pressure on the surface of the liquid in arm **1** becomes more than this predetermined value, then the total liquid in the U-tube becomes incapable of exerting a back pressure on the gas and as a result this column of liquid gets displaced completely into the liquid holder **5** breaking the seal instantaneously as shown in the Figure **IV**. This makes the U-tube empty of the liquid; giving a free passage to the gas to escape through the U-tube to the liquid holder **5** and then through the pipe **6** to the pipe **9** and finally to the flare stack. The excess gas escapes from pipe **8** to the pipe **9** through the now broken liquid seal **L1** and finally to the flare stack **15**. In order to prevent the